Micro-to-Mainframe Communication Standard
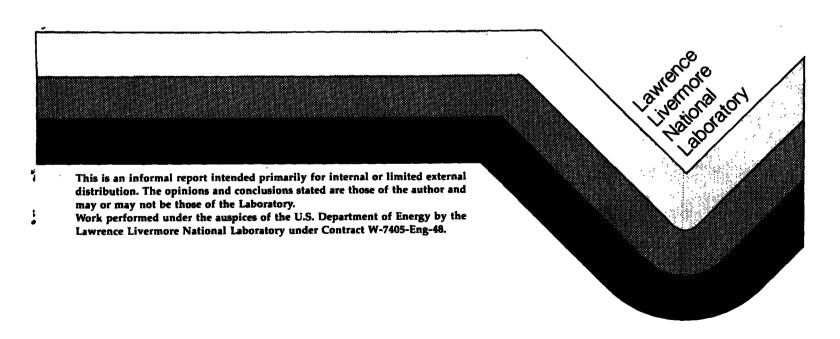
SUBSYSTEM DESIGN ANALYSIS REPORT

September, 1986

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Technology Information Systems

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ACKNOWLEDGEMENTS

EXECUTIVE SUMMARY

The Micro-to-Mainframe Communication Standard (MMCS) project was created in response to the MMCS Statement of Work (SOW) from the Air Force Logistics Command dated August 7, 1985, which calls for the development of a draft standard for micro-to-mainframe communications. This standard is intended for use in the support of AFLCR 700-1 standards. Future uses will include the competitive acquisition of micro-to-mainframe communications capability for the AFLC modernization programs, and support of office automation from a single terminal/workstation for each user.

Along with the development of a proposed communication standard, the MMCS project included performing a technical analysis of microcomputer communications with respect to the functionality required for use with the LOGNET program. This *Subsystem Design Analysis Report* documents the work performed by the MMCS project. It describes the methodology used in the technical evaluation. It also identifies the source materials used in collecting the technical data. Finally, it reports the results of the evaluation work performed.

The results included in this report are:

1. A list of functional criteria to consider when writing a draft standard.

2. A selected set of file transfer protocols and communications software which will meet the AFLC draft standard requirements and can be evaluated in more depth in a follow-on cost/tradeoff study.

The file transfer protocols selected for further evaluation are:

- KERMIT
- BLAST
- Christensen (XMODEM)

The following set of communications software, which uses one or more of the above file transfer protocols, were selected for further evaluation:

•	Ascii Pro	Supports MS-DOS and PC-DOS and Christensen and Kermit protocols.
•	Crosstalk	Supports MS-DOS and PC-DOS and Christensen and Kermit protocols.
•	MITE	Supports MS-DOS and PC-DOS and Christensen and Kermit protocols.
•	Blast	Supports all micro operating systems and the Blast protocol.
•	HyperAccess	Supports Z-DOS and Christensen and Kermit protocols.
•	Lync	Supports Z-DOS and the Christensen protocol.
•	Kermit	Supports Z-DOS and the Kermit protocol.

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Micro-to-Mainframe Communication Standard

Subsystem Design Analysis Report

1. INTRODUCTION

1.1. SCOPE OF DOCUMENT

This report documents the work performed in the implementation of the MMCS project. It describes the methodology used in the technical evaluation towards achieving the MMCS results. It also identifies the source materials used in collecting the technical data. Finally, it reports the analysis results of the evaluation work performed.

Subsequent sections of this report are organized as follows:
- **MMCS project methodology**
  This section discusses the project methodology used to define and manage the MMCS effort.
- **Technical analysis methodology**
  This section discusses the analysis and evaluation procedures used for MMCS.
- **Technical analysis data**
  This section documents in detail the technical data used in the evaluation.
- **Analysis results**
  This section discusses the selection of the file transfer protocols and communications software packages for the cost/trade-off analysis.
- **Bibliography**
  This provides a comprehensive list of articles and publications used or referenced in the MMCS project.
- **Glossary**
  This provides a technical glossary of abbreviations, terms and acronyms used in this document.

A brief overview of the MMCS scope of work is provided in the next section. This information is related to the project technical effort, and consequently has bearing on the rest of the report.

1.2. RELATED DOCUMENTS

The following documents provide background for the Micro-to-Mainframe Communication Standard (MMCS) project. A more comprehensive list of internal project documentation may be found in the *Bibliography* section.

1.2.1. Official SOW and Project Documents

- Micro-to-Mainframe Communication Standard Statement of Work (SOW), dated 7 August 1985.
- MMCS Project Implementation Plan, *Rev. 1*, LLNL HTPE, dated May 1986.

1.2.2. Other MMCS Document Deliverables

Besides the *Project Implementation Plan* and this *Subsystem Design Analysis Report*, the following are two MMCS document deliverables for the first phase of the project.

- Micro-to-Mainframe Communications, Air Force Draft Standard
- MMCS System/Subsystem Trade Study Report

1.3. ANALYSIS OBJECTIVE

The objective of the MMCS technical analysis is to arrive at a standard for micro-to-mainframe communications for the Air Force and to propose a solution for the Air Force that meets this standard. This report identifies the functions to be considered in the Air Force draft standard. It also explains how file transfer protocols and specific communication software packages were selected as possible solutions to the Air Force's file transfer and data communication needs.

2. MMCS PROJECT METHODOLOGY

This section describes the methodology used in the MMCS project for developing a file transfer standard. It also describes the methodology used to arrive at a recommended solution that will later be documented in the *MMCS Subsystem/System Trade Study Report*.

Section 2.1 begins by defining the scope of work for the MMCS project. Section 2.2 describes the task breakdown and explains the methodology employed in the technical analysis effort. Section 2.3 explains how the recommended solution was chosen. A list of the sources for the technical data used to support the study is provided in Section 2.4.

2.1. DEFINITION

2.1.1. Statement of Work Approach

A preliminary analysis of the MMCS scope indicated the need for a generic solution. In considering both asynchronous and synchronous modes of communication between micros and mainframes we chose to address the asynchronous mode. The asynchronous mode offered a better choice for a generic solution in addressing *most* of the micro and mainframe systems that were required to be supported. Choosing only one approach reduced the

project scope to manageable proportions.

Therefore, taking into consideration the time and cost constraints, along with the technical requirements that had to be addressed, we defined the scope of Phase 1 as the following: to do an analysis of current asynchronous communication products and to determine a solution that is compatible with the mainframe and micro systems specified in the SOW.

The synchronous mode would be addressed as time, funding and resources were allocated. Other follow-on work for MMCS that may be addressed at a later time are as follows: host-to-host file transfers, file interchange formats and standards, and application-to-application data exchange.

2.1.2. Project Definition

A preliminary Project Outline and Milestones document was submitted to AFLC within two weeks following the assignment of the SOW to the LLNL TIS staff. This document stated the project assumptions, the proposed scope of work, an initial milestone schedule, and presented an outline of the project task breakdown, and labor and cost estimates.

The initial phase of the project still required clarifications on some requirements in the Statement of Work from the AFLC. Some recommendations for changes in the SOW were proposed by the LLNL MMCS project staff in order to identify those requirements that were most likely to have impact on the initial labor and cost projections.

In summary, defining the project entailed the following steps:

- Analyzing the SOW requirements;
- Defining the deliverables;
- Defining the project constraints;
- Defining a reasonable project scope and solution;
- Defining the project assumptions;
- Performing a task breakdown of the MMCS effort, based on the assumptions;
- Providing a labor estimate for each task in the project;
- Preparing a cost estimate for the project, based on the labor estimate and initial projected costs;
- Defining project milestones that address all of the required SOW deliverables;
- Preparing an initial project schedule for the project milestones;
- Consolidating all of the above information into a project plan contained in the MMCS Project Outline and Milestones document, and subsequently incorporating this information into the official Project Implementation Plan;
- Submitting the plan to AFLC for approval;
- Ongoing communication between LLNL MMCS project staff and AFLC in order to:
  - clarify technical items/requirements in the SOW,
  - request necessary information or documents required for the MMCS effort,
  - obtain approval of the project assumptions and direction, and
  - notify AFLC and obtain approval for changes or updates in the cost or schedule.

2.1.3. Project Updates

Since submitting the Preliminary MMCS Project Outline and Milestones document on 12/13/85, the following events have occurred which have updated the project status and definition. Listed in chronological order, they are:

Date	Originator	Event
01/10/86	AFLC SITE	Modification to SOW Paragraph 2f, dropping the CP/M requirement.
01/23/86	AFLC SITE	Response to the MMCS Project Outline and Milestones document.
01/23/86	Mel Lammers, SITA	Project meeting with AFLC resulted in support of a cost and calendar schedule as proposed by LLNL TIS, with future changes to be mutually agreed upon between AFLC and LLNL.
02/13/86	˙LLNL TIS	MMCS project staff submitted SOW change recommendations to AFLC.
03/13/86	AFLC SITE	Positive response to LLNL's SOW change recommendations, with two items further clarified by AFLC.
03/15/86	LLNL	Assumption of MMCS project management role by Peter Prassinos. Submittal of a draft MMCS Project Implementation Plan with an updated schedule.
03/28/86	AFLC SITE	AFLC Response to the MMCS Project Implementation Plan.
04/02/86	AFLC SITE	Addition of two more mainframe systems (Data General and Tandem) to the host requirements.

2.2. METHODOLOGY

2.2.1. MMCS Work Overview

The MMCS Statement of Work consists of two requests:

1. Definition of a micro-to-mainframe communication standard for file transfer and terminal emulation. This effort will result in a proposed *Micro-to-Mainframe Communication Draft Standard* deliverable document. This draft standard is intended to be a functional standard only, and does not contain any vendor references.

2. Recommendation of a file transfer solution for AFLC that addresses the said standard. This recommendation will be documented in the *MMCS System/Subsystem Trade Study Report* that describes the cost/tradeoff analysis of the recommended solution. The steps used to arrive at the solution is also described in the *MMCS Subsystem Design Analysis Report*. Our intention was to recommend a solution that is currently available, either from commercial sources, government, public domain, or academic or

research institutions.

2.2.2. Project Task Methodology

The technical work for the project consisted of several tasks. Each task is briefly described below:

1. **Data Collection**

   This involved:
   - Obtaining all documents referenced in the SOW;
   - Downloading sources of technical data from online information databases;
   - Obtaining referenced technical articles and publications.

2. **Data Evaluation**

   Analysis and evaluation of the data:
   - Reading and analyzing collected data;
   - Establishing criteria for the evaluation of file transfer protocols and communications packages;
   - Selecting a subset of packages and protocols for verifying functions; .
   - Written evaluations of communication packages and protocols.

3. **Verification of Data**

   This involved:
   - Procurement of selected software communication packages for testing;
   - Obtaining the necessary hardware (microcomputers) and communications equipment;
   - Setup of all hardware, software and telecommunications;
   - Requesting and obtaining access to required communication paths and hosts;
   - Hands-on verification of the selected communications protocols and packages per established functional criteria.

4. **Subsystem Design Analysis Report (SDAR)**

   This includes documenting the results of the data analysis and verification phases. The results of the two functional matrices, the Software Package vs. Communication Functions matrix, and the File Transfer Protocols vs. Protocol Functions matrix, are included in this SDAR report. Also, a bibliography of the technical data sources is included. CDRL DI-S-3581 was specified in the SOW as a guide to the document content and format.

5. **Cost/Tradeoff Analysis**

   This includes determining alternative solutions for the AFLC micro-to-mainframe communications and

file transfer requirements, and performing a cost/trade-off analysis for each solution. The list of trade-off factors is defined and used in the analysis discussion.

6. **System/Subsystem Trade Study Report (STSR)**

Using the results of the cost/trade-off analysis, the recommended solutions are presented to AFLC in this report. CDRL DI-S-3606 was specified in the SOW as a guide to the document content and format.

7. **Draft Standard**

The MMCS proposed draft standard includes:
- The requirements outlined in SOW Paragraph 5c;
- A functional standard for any file transfer protocol to be used by the microcomputers for file transfers between micros and between micros and mainframes;
- A functional standard for communications software which resides on a microcomputer.

2.2.3. Bibliographic Search & Information Collection

A search of bibliographic databases for articles and publications was conducted for the MMCS study in order to get a comprehensive bibliographic reference list. The following outlines how this was done.

2.2.3.1. Keyword Search

Each database has its own conventions used for indexing and querying. Due to the different orientations of each database, slight variations of the search strategy had to be used. Searching was performed using combinations or variations of the following terms or keywords:

Micro(s)
Microcomputer(s)
Mainframe(s)
Communication(s)
Telecommunication(s)
Link(s), linkage, linking

2.2.3.2. Bibliographic Collection

The downloaded files containing the citations were manually screened by the MMCS project staff. Articles or publications that were considered pertinent to the MMCS effort were extracted and are included in the bibliographic references section of this report.

The extracted citations were then forwarded to the LLNL Technical Information Department. Their services were used to extract the articles and materials either out of their own library, or from other libraries using the Interlibrary Loan program. These articles were mailed back to the LLNL/TIS MMCS project staff.

2.2.4. Technical Analysis Methodology

The following is an outline of the steps taken in conducting the technical evaluation effort.

1. The first phase consisted of data collection. One of the methods used was to conduct a bibliographic search on the subject of *micro-to-mainframe links/communications*. DIALOG Information Services Network provided a list of citations on the subject. The databases were searched for certain keywords or combinations of keywords in the title. An LLNL Technical Information Specialist performed the database searching and downloading. (Section 2.4, *Technical Sources*, lists the on-line information databases accessed.)

2. In the next phase, we defined the functional criteria which would be used to evaluate file transfer protocols and communications software. These criteria, consisting of functions or features, were then mapped against a potential list of file transfer protocols and communications software packages to be evaluated. These matrix definitions consisting of *Functions vs. File Transfer Protocols* and *Functions vs. Communications Software Packages* were initially forwarded to AFLC in a preliminary *MMCS Subsystem Design Analysis Report*.

    The *Technical Analysis Results* section (Section 5) of this document contains the evaluation results for the matrices.

3. The next phase entailed performing hands-on evaluation of file transfer protocols for preliminary verification of functionality and an investigation of the viability of specific protocols that might be considered for the standard.

4. After selecting a set of file transfer protocols, we proceeded with a written comparison of 20 micro communications software products against the communications software functional criteria. The following information sources were used:

    *   Vendor product descriptions and manuals;
    *   Data Decisions evaluations on PC Communications (marketed by DataPro Inc.);
    *   One Point On-line Database services.

5. After completing the individual evaluation (check-off) sheets for protocols and communications software, the results were compiled into the *Functions vs. Protocols* and *Functions vs. Communications Software* matrices.

6. Based on the results of the evaluation matrices, a selection was made of communications packages for verification of functions and for the cost/trade-off analysis effort. The criteria for selection included meeting all of the AFLC SOW requirements.

7. Conclusions were drawn as a result of this technical analysis effort and have been documented in this report. These conclusions are the precursor to the Cost/Trade-off Analysis of the MMCS project, and to the specification of the MMCS draft standard.

The following restates in outline form the evaluation methodology applied to the file transfer protocols and communications software packages.

2.2.4.1. File Transfer Protocols

1. Define the functional criteria to be used for evaluation of file transfer protocols.

2. Determine which file transfer protocols are to be evaluated.

3. Perform a written evaluation of the protocols based on their documented specifications using the evaluation sheet.

4. Perform a hands-on evaluation of these protocols using the evaluation form to verify functionality required by the SOW and the other protocol features in the list.

5. Compile the evaluation results in the *Functions vs. File Transfer Protocols* matrix. Analyze results for possible recommendations.

6. Document problems encountered during the actual verifying of the file transfer protocols.

7. Choose which protocols should be considered in recommending a file transfer solution.

8. Select the functionality for file transfers to be specified and included in the MMCS standard. (This task was done during the drafting of the standard.)

2.2.4.2. Communications Software

1. Define the functional criteria to be used for the evaluation of communications software. Make distinctions between required functionality (SOW requirements) and desirable functions.

2. Determine which communications software packages are to be evaluated, based on criteria that includes support for file transfer. This first-level screening assures the product's compatibility with the possible solution and compliance with SOW requirements.

3. Complete a written evaluation of the communications software using the evaluation sheet which is based on several product information sources.

4. Compile the evaluation results in the *Functions vs. Communications Software Packages* matrix. Analyze results for possible recommendations.

5. Determine criteria for which protocols/communications software should be considered for the solution(s) in the cost/trade-off analysis effort.

6. Choose 5 to 6 communications packages for hands-on evaluation and verification. These packages shall be considered in recommending a file transfer solution for the Air Force.

7. Select the functionality for communications software to be specified and included in the MMCS standard. (This task was done during the drafting of the standard.)

2.3. THE APPROACH TO FINDING A SOLUTION

1. **Asynchronous Communications vs. Synchronous Communications**

   As mentioned earlier, given the required micro and mainframe systems specified in the SOW, we felt that the asynchronous approach would provide a more generic solution for the following reasons:

   • Asynchronous communications are generally available on most of the specified mainframe systems (with IBM, protocol converters can be acquired);

- Micro-to-micro communications generally use asynchronous ports. This is the prevailing industry standard and is available with most micro systems that offer communication ports.

- One task of the project was to find potential solutions for file transfers of ASCII text (where binary transfers were not required). The asynchronous mode sufficiently addresses this type of communications usage. Since higher baud rates are becoming more common in the newer communications equipment currently available, performance in terms of speed of transmission is becoming less of an issue for textual file transfers.

- Although synchronous communications are more efficient in large block transmissions, such as specialized full-screen application terminals or graphics terminals, for terminal emulation purposes that assume human interaction, the asynchronous mode suffices for character-by-character or line-by-line interaction with the host mainframe.

- Protocol converters are commercially available to convert asynchronous protocols into synchronous when communicating with mainframes or communications processors that expect synchronous protocols.

Given that binary data may be a future consideration for Air Force micro-mainframe links (e.g., bit-map or full screen graphics data) where data volume becomes a major issue, the synchronous vs. asynchronous modes of transmission would merit serious attention when considering performance for this type of communication.

However, we have confined the scope in this phase of the MMCS effort to the asynchronous mode of communications, since this mode offers a more generic, less costly approach towards an Air Force-wide solution to micro-to-mainframe text file transfers and terminal emulation problems.

2. **File Transfer Protocols**

In determining which protocols to evaluate, we researched existing file transfer protocols for file transfers that most closely approximated the presentation layer of the Open System Interconnection (OSI) seven-layer reference model from the International Organization for Standardization (ISO).

After compiling a list of qualifying file transfer protocols, we performed comparative evaluations and chose those offering the most features, while concurrently satisfying the most SOW requirements. A group of file transfer protocols was chosen as recommendations for AFLC. These protocols were then included in the criteria for the selection and evaluation of communications software packages.

3. **Communications Software**

Based on evaluative material from our bibliographic sources, we chose twenty software packages according to certain criteria. The most basic and mandatory criteria are listed below. Software packages that do not meet the following criteria were not considered for the generic solution. A software package that did not qualify was considered only if it contained a feature that met a requirement not available with the other packages (*see Exception Cases section below*).

- Support for one or more file transfer protocols;
- Terminal emulation capabilities;
- Support for the specified micro operating systems: PC-DOS, MS-DOS, Z-DOS.

4. **Exception Cases**

    Not all communication software packages meet all of the MMCS requirements and support the recommended file transfer protocols. In cases where there was a requirements gap, we addressed each requirement individually with specific protocol/software package solutions. These solutions were added to address or fill specific MMCS requirements that weren't addressed by the other selected protocols and communications packages.

2.4. TECHNICAL SOURCES

2.4.1. Bibliographic Databases

The DIALOG™ Information Retrieval Service was used to extract bibliographic citations on the subject of micro-mainframe communications. The LLNL/TIS system was used to connect to DIALOG and download the citations onto a local file. The following list shows the databases accessed via DIALOG.

Database Source	*Origin*
1. The Computer Database	Management Contents Northbrook, IL • 800-323-5354
2. Information Science Abstracts	IFI/Plenum Data Company Wilmington, DE • 302-998/0478
3. Magazine Index	Information Access Corporation Menlo Park, CA • 800-227-8431
4. Microcomputer Index	Microcomputer Information Services Santa Clara, CA • 408-984-1097
5. ABI/INFORM	Data Courier, Inc. Louisville, KY • 800-626-2823

2.4.2. Online Information Database

Product information on particular communications products was downloaded (at minimal cost) to aid in the evaluations. The One Point On-Line Database of product descriptions and pricing information was accessed for this purpose.

2.4.3. Datapro's Evaluation Service

For general in-house TIS use, we purchased a subscription to the Data Decisions PC Communications. This consists of three large volumes containing evaluative information on PC communications products, which is updated monthly. The information includes product descriptions, product ratings, product information, and hands-on evaluations. These volumes were valuable in providing reference material for the written evaluations of most of the communications software packages we investigated.

Product: **Data Decisions PC Communications**

Vendor: Datapro Research Corporation
             1805 Underwood Blvd.
             Delran, NJ 08075
             409-764-0100

3. TECHNICAL DATA AND ANALYSIS

This section documents the technical data used in the evaluation of asynchronous communications for micro-to-mainframe links. It lists the project technical assumptions, SOW requirements and design constraints on the MMCS technical effort. Additionally, it provides a detailed description of the criteria used for evaluation of file transfer protocols and communications software.

3.1. ASSUMPTIONS

The following assumptions were made for this phase of the MMCS project:

1.   This standard and solution addresses transmission of any ASCII file. For this project, a *file* is defined as a string of ASCII characters which may be transmitted across any communication link in units of 8-bit bytes, where each byte contains a 7-bit ASCII code.

2.   The logical interpretation of the ASCII file shall be preserved from the sender host's native form to the receiving host's native form. Although we cannot assume physical compatibility between different hosts in how files are stored, we shall assume that we can preserve the file's logical compatibility, based on the above definition of an ASCII file.

3.   Although unstated as a requirement, for data transmission between a microcomputer and other hosts, we specified the prevailing industry-standard communication baud rates of 300, 1200, 2400, 4800, 9600 and 19,200. They should be compatible with the AFLC LAN specifications.

3.2. DESIGN REQUIREMENTS & CONSTRAINTS

This section lists the SOW requirements for the evaluations and design constraints considered in proposing a solution which meets the AFLC file transfer and terminal emulation needs.

3.2.1. Design Constraints

This section lists the design constraints adopted by the MMCS project for the evaluations.

1. All micro computer data will be transmitted asynchronously to electrical interfaces using EIA standard RS-232C (the international version is CCITT V.24) interfaces to data communications equipment (DCE).

2. Data will be transmitted at prevailing industry-standard communication baud rates, i.e., 300, 1200, 2400, 4800, 9600, 19,200 baud (*see assumption 3 above*).

3. For the 300 and 1200 baud rates, Bell 103- and 212A-compatible modems will be used for evaluations.

4. For the higher baud rates (2400, 4800, 9600 baud), modem or communications equipment conforming to applicable data communications standards should apply (e.g., CCITT's V.22 *bis*, V.26 *bis*, V.27, V.29).

3.2.2. AFLC-Specific Requirements

This section lists capabilities that are specific to AFLC requirements, and will be included in the MMCS draft standard.

3.2.2.1. Compatibility with AFLC Networks

*   AFLC Local Area Networks (LANS).
    Micro computers will interface with the TRW Concept 2000 LAN by means of the asynchronous RS-232C interface. (The draft standard shall specify the synchronous interface also.)

*   Defense Data Network (DDN) and Intersite Gateway Processors (ISG).
    Micro computers will access the DDN via an ISG residing on the LAN. The Intersite Gateway Processor will handle protocol conversions between the LAN and DDN networks.

3.2.2.2. Communication with Micros

Micro-to-micro communications shall be supported for the micro operating systems listed below. For evaluation purposes, the following micro computers below shall be used with the associated operating systems. There are many other micro computers which would also qualify for use in these evaluations.

Operating System	Micro Computer
• MS-DOS	Zenith 150
• PC-DOS	IBM-PC
• Z-DOS	Zenith 100

3.2.2.3. Communication with Mainframe Systems

Micro-to-mainframe communications shall be supported for the following mainframe systems:

- Unix 4.2 BSD with LLNL TIS enhancements.
- AT&T Unix System V Release 2
- IBM MVS/TSO
- IBM VM/CMS
- CDC NOS/BE
- DEC VAX/VMS
- Sperry OS/1100 EXEC
- Data General AOS/VS *(recently added requirement)*
- Tandem OS/Guardian 90XF *(recently added requirement)*

3.2.3. AFLC Compatibility Requirements

AFLC compatibility requirements will not be listed in the matrix tables. The resulting analysis report may indicate potential incompatibilities that may have been discovered.

- Compatibility with *Air Force Zenith Standard Micros*
- Compatibility with *Air Force Standard Small Computer Multiuser Workstation*
- Compatibility with AFLC LAN Bus Interface Units

3.3. CRITERIA FOR EVALUATION

This section contains the features selected for evaluation by the MMCS project. These features are to be considered for inclusion in the draft standard. They are also used to evaluate the viability of potential solutions.

The features are grouped into two categories for clarity and organization:
 1. Features resident in a file transfer protocol
 2. Features resident in user level communications software

The features available in the file transfer protocol are a subset of the features needed for user level communications software. In deciding upon a solution, the file transfer protocols must be selected first, followed by a communications software application which uses the selected file transfer protocols. In other words, the communications software solution is dependent on the file transfer protocols selected.

3.3.1. File Transfer Protocols

This section provides a brief description of the functional criteria used to evaluate file transfer protocols for the MMCS standard and solution. The criteria are separated into the following groups:

 1. AFLC Network Support
 2. File Types Supported
 3. Error Detection and Recovery
 4. Control Code Handling Options
 5. Data Security
 6. Other Features

1.   AFLC Network Support

The standard must ensure accurate data transmission between microcomputers using the AFLC LANs, Intersite Gateways and DDN, as applicable for local and intersite transfers.

Functional Capability	Requirement	Description
Data preserved across DDN	√	Files transmitted between hosts must be accurately transmitted if the hosts are connected via the Defense Data Network.
Data preserved through an ISG	√	Files transmitted between hosts must be accurately transmitted if the hosts are connected via an Intersite Gateway.
Data preserved across AFLC LANs	√	Files transmitted between hosts must be accurately transmitted if the host connections are through the AFLC Local Area Network.

2.   File Types Supported

This describes the file types to be supported in the micro-to-micro and micro-to-mainframe file transfers.

Functional Capability	Requirement	Description
Transfer 7-bit ASCII Data Files	√	The transfer of ASCII data files between micros or micros and mainframes is a required capability. This deals with the transfer of files containing 7-bit ASCII data bytes.
Binary File Transfer	-	This involves the transfer of all 8 bits for every byte in the file with data transparency, i.e., any bit pattern may be transmitted without regard to its interpretation as control characters.

3. Error Detection and Recovery

Some error detection capability and recovery handling is a mandatory requirement for file transfers.

Functional Capability	Requirement	Description
Error Checking and Retransmission	√	Error checking capability must detect error conditions in the file blocks sent, such as block-out-of-sequence or incorrect number of bytes, and must have the ability to recover from such errors by requesting a retransmission of the block in error.
Resume File Transmission after Sudden Shutdown	√	Ability to resume transmission of a file after involuntary shutdown from the point where the interruption occurred in the file transfer.

4. Control Code Handling Options

ASCII control codes are the non-printing characters represented by codes 000 - 037 octal.

Functional Capability	Requirement	Description
Transmit any Control Codes	√	Capability to transmit any of the ASCII defined control codes without interpretation or loss.
Filter Incoming Control Codes	√	Filter Selected Control Codes on Input provides the capability on the receiving host to select specified control codes and not deliver them to the target file.
Retain Selected Control Codes	√	Filter Selected Control Codes on Output provides the capability on the source host to select specified control codes and not transmit them out to the target host.
Redefine Control Codes at Both Ends	√	The ability to redefine control code handling at both ends of a host communication link at the time of a file transfer.

5. Data Security

These are features that insure protection of data being transmitted from unauthorized access, purposeful or inadvertent destruction.

Functional Capability	Requirement	Description
DES encryption available for file transfers	-	DES encryption prior to outgoing transmission of files and decryption after receipt of a transferred file.
Other encryption scheme available	-	RSA or other data encrypting scheme available.
Password Protection	-	Capability to require a password query before file transfer takes place.
Multiple Level Security	-	*Multiple Levels of Passwords* is the ability to enforce different password protection schemes depending on whether or not the file is being transmitted out (read) or received (written) on the initiating host.

6. Other Features

This is a group of miscellaneous features which should be included in considering a draft standard.

Functional Capability	Requirement	Description
Data Compression Capability	-	Allows the 'squeezing' of data for the purpose of output. This squeezing can be done on a character basis by reducing the character size of transmitted and received characters, as well as on a message basis by eliminating redundant characters.
Vendor Proprietorship	-	Is the protocol definition under the public domain or is it a proprietary definition? This issue will become more important in a follow-on Cost Trade-Off Analysis when features such as maintainability, version availability and support will be addressed.
Translation to 7-bit data	-	Ability to transmit 8-bit data bytes across network paths which transmit only 7-bit data bytes.

3.3.2. Communications Software

As a result of the data analysis from the bibliographic data collected, we decided to use the following criteria when evaluating software packages.

We looked at the following basic areas:

1. Micro Operating Systems Supported
2. File Transfer Protocols Supported
3. Communication Options Available
4. Terminal Emulation Capabilities
5. Data Filtering and Translation
6. Usage Features
7. Configuration Features
8. Security - Data Encryption Protection
9. Security - Data Access Protection
10. File Transfer Statuses
11. Miscellaneous Features

This section provides a description of the functional criteria which was used to evaluate communications software for the MMCS standard and solution.

1. Micro Operating Systems Supported

Functional Capability	*Requirement*	*Description*
MS-DOS	√	Operates on IBM PC compatibles.
PC-DOS	√	Operates on IBM PC.
Z-DOS	√	Operates on Zenith 100's.

2. File Transfer Protocols Supported

The following protocols are included within the matrix because they either provide a practical alternative while meeting all or most of the requirements, or (as in the case of Christensen) its inclusion provides some flexibility not available otherwise.

Functional Capability	*Requirement*	*Description*
Christensen (XMODEM)	†	Provides error-detecting and retransmitting capabilities, however due to its usage and transmission of binary numbers and control codes, unpredictable results may occur in some networks. If there is a desire to communicate with non-DDN microcomputers, this protocol is extremely useful, because most microcomputers and modems will have it available to them.
KERMIT	†	Satisfies most of the SOW requirements, including near universal availability in source code for mainframes. The single requirement that KERMIT does not meet is for data transmission resumption after involuntary shutdown.
BLAST	†	BLAST is an asynchronous, full duplex, interleaving protocol that provides a faster transfer rate than KERMIT, and is available on most mainframe systems. It is the only protocol of the three that advertises transmission resumption after involuntary shutdown. Evaluation of data transparency through a network has not been evaluated at this time, but BLAST is believed to be certified by TYMNET. On paper, BLAST appears to satisfy all of the requirements of the asynchronous file transfer protocol.

† To be determined as the result of the MMCS Cost Tradeoff Analysis recommendation for file transfer protocol usage.

3. Communication Options Available

Micro-computers can communicate with other micros and mainframes at the the baud rates in the chart below, or higher. They are connected to other machines by Data Communications Equipment (DCE).

Functional Capability	*Requirement*	*Description*
1200/300 Baud Rate	√	Connections via direct connect or modem using Bell 103 (300 baud) or Bell 212A (1200 baud) standards.
2400 Baud Rates	-	Connections via direct connect hookup or communications modem equipment.
4800 Baud Rates	-	Connections via direct connect hookup or communications modem equipment.
9600 Baud Rates	-	Connections via direct connect hookup or communications modem equipment.

4. Terminal Emulation

To satisfy the SOW requirements, the software package must provide the capability for a microcomputer to be used as an interactive terminal when connected to a mainframe. Almost all communications software provide this. A further enhancement might be the software's ability to "act like" or emulate one of the widely used terminals that have full-screen capabilities. If the terminal is intended for use with a mainframe system's full screen editor, for example, emulation of a terminal the computer "recognizes" is necessary.

Function Capability	Requirement	Description
Interactive Terminal Emulation	√	Allows a microcomputer to emulate an interactive terminal which interacts with a host computer. Interactive terminals vary in their abilities. The most basic terminals display data one line at a time on the screen. This is often referred to as TTY mode, and the emulation of this terminal mode is often called TTY emulation.
VT100 Emulation	-	Allows a microcomputer to emulate a VT100 terminal. VT100 terminals are one of the most popular terminals which full-screen applications on mainframes support, particularly when the applications are executing on the VMS or UNIX operating systems.
VT102 Emulation	-	Allows a microcomputer to emulate a VT102 terminal. The VT102 is an upgraded version of the VT100. Applications which support VT100 terminals also support VT102 terminals.
Other full-screen terminal emulation	-	Allows a microcomputer to emulate other types of terminals. (e.g. IBM 3101 terminals are frequently used to allow asynchronous terminals to talk with IBM host operating systems through a protocol converter.)

5. Data Filtering and Translation

At the terminal level, the end-of-line is controlled by a carriage return line feed (<CR><LF>) sequence as the terminal is receiving data, and by a carriage return when data is sent from the terminal. This is standard timesharing methodology. In addition, there may be a desire to filter out or translate other control codes. This is because the PC is, in itself, an intelligent terminal which uses incoming codes to control its screen. Also, the use of a full-screen editor may require the use of control codes from the keyboard, which must be filtered from the internal PC software in order to be sent to the host.

Function Capability	Requirement	Description
Convert PC End-of-Line to Host End-of-Line	√	Often called *Delete and/or add linefeeds* or *Redefine newline character* in product literature. This is the ability to redefine the character which separates lines in an ASCII text file. In most cases this is a carriage return (<CR>) line feed (<LF>) sequence, or a single carriage return. If the two communicating machines do not use the same technique, one of the two computers must adjust the function to whatever the other expects.
Convert tabs to spaces	√	The ability to convert outgoing tabs to spaces is desirable for communication with applications on mainframes, which do not have the ability to interpret the tab, and therefore display information on the screen as desired.
Filter Selected Control Codes on Output	√	The ability to filter out selected control codes from the file prior to transmission.
Filter Selected Control Codes on Input	√	The ability to filter out selected control codes from the incoming data prior to storing it onto a file.
Strip High Data Bit	-	The ability to strip the high-order data bit out of each 8-bit byte in the data.

6. Usage Features

These features provide a human interface to simplify use by the operator.

Function Capability	Requirement	Description
Functional screen menus	√	This involves access to the features and capabilities of the communications package through the use of standard consistent screen menus. Easy to understand options are displayed on the screen, with clear indication of the possible responses.
On-screen help facility	-	Clear and understandable information about commands and options displayed to the user upon request.
Tutorials (cassette or online)	-	Learning material which, as part of the software package, provides the user with sufficient self-training to effectively use the software.

7. Configuration Features

Function Capability	Requirement	Description
Automated command sequence setup	-	Sometimes referred to as 'programmable macros.' An example might be to: 1) select baud rate, 2) set parity, 3) set half duplex, 4) make connection, 5) dial number, 6) redial after 30 seconds if no answer, 7) go to menu B upon answer, etc. This entire sequence may be defined into one command, such as CALLDOD, or into a menu number; then used later by typing "calldod" or the menu number.
Function key definitions	-	A command or series of commands defined into a function key so it may be executed by pressing the key.
Unattended operations setup	-	An example of this might be a setup for auto-answer, verification of security, and receipt of a file automatically in unattended mode, without user intervention.

8. Security/Data Encryption Protection

Features that ensure protection of the transmitted data from unauthorized access or purposeful or inadvertent destruction. Encryption schemes are not necessarily performed at this level of data transmission. It is often performed as a function of the approximate ISO *session* level (e.g., in the communications modem).

Function Capability	Requirement	Description
DES (Private Key)	-	Implementation of the DES private key encryption technique for encrypting data prior to outgoing transmission and for decrypting incoming data.
RSA (Public Key)	-	Implementation of the RSA public key encryption technique for encrypting data prior to outgoing transmission and for decrypting incoming data.

9. Security/Data Access Protection

Function Capability	Requirement	Description
Password protection	-	Feature that prompts the user for a password prior to allowing access at various levels of a system, resource, database or file hierarchy.
Multiple levels of password	-	Feature that prompts the user for a password at varying levels of access to a system, resource, database or file hierarchy.
Callback	-	This feature enables the host computer being accessed to drop the line and call the requesting user's modem back at a pre-specified number/location from a stored list of users and corresponding numbers (if the user has access permission at the time of host access request).
Access Security within Unattended Operations	-	Feature that prompts remote user for password before allowing access to the local unattended computer.
Interactive Special Knowledge	-	A feature that queries the user for information that is known only to the user in order to provide better identification prior to allowing access to a system, resource or a file. Examples of this are prompts for a driver's license number, personal identification number, or mother's maiden name.

10. File Transfer Statuses

These features display status indicators on the screen, either during the file transfer, or at the end of the file transfer.

Function Capability	Requirement	Description
Character Counts	-	Displays the number of characters transferred either during the file transmission or at the end of the file transfer.
Percent of File Transferred	-	Displays the percentage of the file that has been transferred.
Number of Errors	-	Displays the number of errors (presumably recovered) encountered during file transmission.

11. Other Features

These are features which provide additional services or information to the user, such as how far and how long the process has taken, and when it will be done. User may want to preserve what comes in on the screen by saving it to a file or printing it, or may discard it.

Function Capability	Requirement	Description
Character count during file transfers	-	Provides a progress count on the screen of the number of bytes transferred during a file transfer, with the total number of bytes displayed at the end.
Data Capture	-	Ability to save all incoming data to a file. In the absence of file transfer protocols, this is a common way to download files from a host to a micro.
Unattended transmission of files	-	Allows the invoking of a file transfer without user intervention during the transfer.
Remote Unattended Operation	-	Allows the operation of a computer from remote access without requiring the intervention of an operator.
Toggle printer on/off	-	The ability to turn the printer on or off at any time during data transmission, and have the data flushed to the printer in parallel to the screen display.
Display clock	-	Ability to display the time-of-day on the screen.

3.4. SELECTIONS FOR EVALUATION

3.4.1. File Transfer Protocols

In determining which protocols to evaluate, we looked at existing protocols for file transfers that most closely approximated the presentation layer of the Open System Interconnection (OSI) seven-layer network model from the International Organization for Standardization (ISO).

Given a list of these candidate file transfer protocols, we performed a comparative evaluation of these protocols and chose the ones offering the most features while also satisfying the most SOW requirements.

Out of our survey of file transfer protocols that most closely approximated the presentation layer of the ISO's open system interconnection (OSI) seven-layer model, there was a very limited selection of protocols that are commercially available or available in the public domain.

X.PC and MNP were not included in this evaluation because by definition, they are session level protocols, and do not merit comparison with file transfer protocols like FTP, which exist at the presentation level.

The protocols that qualified for evaluation for an MMCS file transfer solution are listed below. These protocols are included in the criteria for the selection and evaluation of communications software packages.

- KERMIT

- BLAST

- CHRISTENSEN

Other protocols we considered were:

- FTP

    FTP is used widely for mainframe-to-mainframe transfers. However, there was limited availability in the micro communications industry. We are including it here since it will potentially play a significant role in the file transfer solution for the Air Force and its integration into LOGNET. Some of its functional capabilities as a protocol may also be considered for inclusion in the MMCS draft standard. Upon further availability of FTP in micro communications software, it should be seriously considered as a future file transfer solution for Air Force micro-to-mainframe usage.

- X.25

    While presumably X.25 has a protocol defined for file transfers at the presentation level, our bibliographic research did not uncover any implementation, commercial or public domain, that would enable us to perform a hands-on investigation.

3.4.1.1. Protocol Descriptions

This section provides a brief description of the *File Transfer Protocols* investigated for the MMCS project.

3.4.1.2. FTP

Theoretically, FTP is an obvious choice for a protocol standard, as it is currently used by the military for its Defense Data Network (DDN) host-to-host protocols. However, it is not widely available in the micro communications industry yet. Although a few vendors have recently begun to offer an FTP implementation on their communication products, it will be a while before FTP gains commercial acceptance.

Although FTP is not currently a viable option in micro-to-mainframe communications, it is the DOD-chosen protocol for host-to-host file transfers between mainframes. Based on our preliminary hands-on evaluation, to fully integrate the file transfer solution into the Air Force Logistics Network (LOGNET), FTP may be the only current effective and efficient method with which to transfer files between a host gateway processor (e.g., an IGP) and a remote host, when addressing a micro-to-remote host file transfer via DDN route.

3.4.1.3. CHRISTENSEN

The Christensen protocol, more popularly known as XMODEM or MODEM7, was developed in the early days of CP/M by Wade Christensen. (XMODEM and MODEM7 are both implementations of the Christensen protocol; however, widespread usage has equated the term *XMODEM* with the protocol. The terms *Christensen protocol* and *XMODEM* may be used interchangeably in this document.) The Christensen protocol is in public domain, and has been the prevailing file transfer protocol of the various CP/M user groups in the United States. Since the advent of the IBM PC, it has become widely used in the various IBM PC user groups. XMODEM is popular for micro-to-micro transfer of text files, binary object programs, and data-compressed text to and from the many microcomputer bulletin boards because of its ability to transfer 8-bit data in an error detecting/retransmission mode. As a result of its popularity, most communications software vendors have incorporated XMODEM into their products.

File transfer with XMODEM is accomplished by transmitting fixed length packets containing a block of 128 bytes, a header containing an SOH (start-of-header), record number, and the ones-complement of the record number. Early versions used an 8-bit checksum instead of the CRC. Response from the receiving computer is either an ACK or NAK, depending on the detection of an error in transmission. Transmission is with no parity, since the high-order bit is significant. Loss of the initial SOH will usually cause the transmission to hang.

If used through networks, XMODEM has a disadvantage of insufficiently "hiding" the binary bytes in transmission to prevent the network from detecting and using them for its own transmission controls. Unpredicatable results may occur in some networks due to XMODEM's usage and transmission of binary numbers and control codes.

3.4.1.4. KERMIT

KERMIT is a protocol originating out of the Columbia University and is in the public domain. It was developed to facilitate data transfer between diverse types of computers through almost any kind of communications environment. Its early version is capable of ensuring transparency in the transmission of textual materials. In Version 2, it is capable of transmitting binary and textual material transparently, as well as communicating the modes that the data and control packets are to be transmitted in from the originating host to the receiving host.

The sending computer simply sends packets one at a time, and waits for an ACK or NAK packet from the receiving computer before sending the next packet. KERMIT normally assumes transmission of 8-bit data bytes, but if the hosts require the high-order bit to be used for parity, it can use a 7-bit quoting mechanism to send 8-bit bytes. Kermit operates in half duplex, and does not assume that the hosts are capable of full duplex. Kermit makes no assumption about the use of XON/XOFF or any other flow control, and is not tied in any way to the communications baud rate.

KERMIT operates at about 50% - 80% efficiency (user bits / baud rate). This does not compare very well with some existing mainframe-to-mainframe protocols which can stack many packets in sequence and transmit in a full-duplex asynchronous operating mode.

Through the 7-bit quoting mechanism, all characters that are not within the 40 octal through 176 octal (space through tilde) printable character range may be quoted within this range. This makes KERMIT a practical candidate for micro-to-mainframe binary or text file communications directly, or through any existing network, without undesirable or catastrophic network response triggered by the transmission of characters identified as network controls.

Mainframe and micro source code is available from Columbia University for all of the SOW-specified mainframes.

3.4.1.5. BLAST

BLAST is a proprietary product of Communications Research Group. It is available on all of the required mainframe systems listed in the SOW except Sperry/EXEC8 and CDC NOS/BE. On the IBM systems, it requires a special *Blast Box*, an intelligent communications processor designed specifically for this protocol to work with IBM.

Its chief advantage is its speed, since it operates in full duplex "asynchronous" mode using what the manufacturer describes as a "sliding window". Its data and handshaking messages are sent in an interleaving mode, and error recovery requires retransmission of only that data found to be in error. BLAST is the only protocol under consideration that meets the SOW requirement of error recovery after involuntary shutdown. The advantage of this is that progress is not lost on a very large file transfer if either computer aborts processing during transmission of the file. Usually, when a computer goes down, whatever progress has been made is lost because the transmission has to be restarted from the beginning.

Control code and 8-bit transfer methodology are undetermined in our research at this time. This is an important area for further research, since this determines the ability to transfer data through the various networks that will be used. The primary disadvantages with BLAST are its documentation, its unfriendliness to the user, and the fact that it does not have the ability to send files in a "batch" mode.

3.4.2. Communications Software

The communications software packages to be evaluated were selected based on a combination of the following:

- That it meets the minimum selection criteria, i.e.,

    1. support for one or more file transfer protocols,
    2. terminal emulation capabilities,
    3. support for the required micro operating systems: PC-DOS, MS-DOS, Z-DOS.

- Highly rated by independent studies or evaluations,
- Recommendations from various sources, such as LLNL,
- Current usage of and/or requested evaluation for a specific product by the Air Force.

We performed a written evaluation on twenty selected communications software packages. Each of these packages contains an entry in the *Functions vs. Communications Software Packages* matrix, where each package was checked against a list of functional criteria.

The table on the next page shows the twenty asynchronous communications software products that were selected for the written evaluation. Out of this list of twenty, we made our selections few for the proposed Air Force solution (with alternative choices included).

	Micro Communications Packages Evaluated	
	Product Name	*Vendor*
A.	ASCII-PRO	United Software Industries
B.	ASCOM IV	Dynamic Microprocessor Associates
C.	BLAST	Communications Research Group
D.	CROSSTALK	Microstuf, Inc.
E.	HYPERACCESS	Hilgraeve Inc.
F.	IMPERSONATOR	Direct Aid, Inc.
G.	INTELLITERM	MicroCorp
H.	KERMIT	Columbia University
I.	LYNC	Norton-Lambert Corp.
J.	MITE	Mycroft Labs Inc.
K.	OMNITERM II	Lindbergh Systems
L.	PC-TALK III	The Headlands Press, Inc.
M.	PERFECT LINK	Thorn EMI Computer Software Inc.
N.	RELAY	VM Personal Computing Inc.
O.	SMARTCOM II	Hayes Microcomputer Products
P.	SMARTERM 100, 125, 400	Persoft Inc.
Q.	SOFTERM PC	Softronics, Inc.
R.	TANGO	COSI, Inc.
S.	TRANSEND PC COMPLETE	Transend Corp.
T.	VTERM III	Coefficient Systems Corp.

4. TECHNICAL ANALYSIS RESULTS

This chapter documents the results of the evaluations. It includes the selection of the file transfer protocols, the communications software, and the functionality to be included in the MMCS draft standard.

4.1. EVALUATION RESULTS

The following table shows the evaluation results, in matrix form, of the file transfer protocols and the functional criteria.

FILE TRANSFER PROTOCOLS

Functions vs. Protocols Matrix

Protocol Name	Christensen	KERMIT	BLAST
Mainframe Systems Supported			
• AT&T UNIX V.2		√	√
• CDC NOS/BE		√	-
• DEC VAX/VMS		√	√
• IBM MVS/SP		√	√
• IBM MVS/XA		√	√
• IBM VM/CMS		√	√
• Sperry OS 1100/EXEC8		√	-
• UNIX 4.2BSD/TIS	√	√	√
Microcomputer Systems Supported			
• PC-DOS	√	√	√
• MS-DOS	√	√	√
• Z-DOS	√	√	√
Function/Feature			
AFLC Network Support			
• Data Preserved across DDN	-	√	√
• Data Preserved through an ISG		.	
• Data Preserved through AFLC LANs			
Types of Data			
• 7 bit ASCII Data Transfer	√	√	√
• Binary Data Transfer	√	√	√
Error Detection & Recovery			
• Resume file transmission after sudden shutdown	-	-	-
• Automatic error retransmission of errors & autodisconnect after # of attempts	√	√	√
Control Code Handling			
• Allow Transmission & receipt of any ASCII, including control codes	√	√	√
• Transmit any Control Codes	√	√	√
• Filter Incoming Control Codes	-	-	√
• Retain Selected Control Codes	-	-	√
• Redefine Control Codes at both ends in real time	-	-	√
Data Security			
DES Encryption available for File Transfers	-	-	-
Other Encryption Scheme Available	-	-	-
Password Protection	-	-	-
Multiple Level Security	-	-	-
Other Features			
• Data Compression Capability	-	-	-
Vendor proprietorship	PD	PD	CRG
Translation to 7-bit data	-		√

* = Mandatory function/feature   √ = yes
  - = no
  <blank> = undetermined
  PD = Public Domain
  CRG = Communication Research Group

MICRO COMMMUNICATION PACKAGES

Functions vs. Software Matrix

Features	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Micro Systems Supported																				
MS-DOS*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
PC-DOS*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√		
Z-DOS*		-		-	√	-	-	√	√	-				-	-	-	-	√	-	
File Transfer Protocols																				
Christensen (XMODEM)	√	√		√	√	√	√	-	√	√	√	√	√	√	√	√	√	√	√	√
KERMIT	√	-		√	√	-	√	√	-	√	-	-	-	-	-	-	-	-	-	√
BLAST	-	-	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Other		√		√		√	√	-	√	√	-		-	√	√	•P			-	√
Communication Options*																				
1200/300 Baud*	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
2400 Baud	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
4800 Baud	√	√	√	√		√	√	√	√	√	√	√	√	√	√	-	√	√	√	√
9600 Baud	√	√	√	√		√	√	√	√	√	√	√	√	√	√	-	√	√	√	√
Terminal Emulation*																				
Interactive Terminal Usage*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
VT100 Emulation	√	√	√	√	√	√	√	√	-	√	√	-	-	√	√	√	√	√	-	√
VT102 Emulation	-	-	-	-		-	-	√	-	√	-	-	-	√	√	-	-	-		√
Other Full Screen	√	√	√	√	√	√	-	√	-	√	√	√	√	√	√	√	√	√	-	√
Data Filtering & Translation																				
Convert PC End-of-Line to Host EOL	√	√	√			√	√	-	√	-	√	√	-			-		-	√	√
Convert Tabs to Spaces		√	-	-		√	-		-	-	√	-	-		-			-	√	-
Filter Selected Control Codes on Output	-	√	√	√		√	√	-	√	-	√	√	-			-		√	√	√
Filter Selected Control Codes on Input	√	√	√	√		√	√	-	√	-	√	√	-				√	-	√	√
Strip High Data Bit	√	√	√	√		√	√	√	√	√	√	-	-		√			√	√	√
Usage Features																				
Functional Screen Menus*	√	√		√		√	√	-	-	√	√	√	√	√	√	√	√	-	√	√
On Screen Help facility	√	√	-	√		√	√	√	√	√	-	√	√	√	√	√	-	-	√	√
Tutorials	-	√	-	-		-	-	-	-	-	-	√	√	-	-	-	-	-	-	-
Configuration Features																				
Automated Command Sequence/Setup	√	√		√	√	√	√	√	√	√	√	√	√	√		√			√	√
Function Key Definitions	√	-	-	√	√	√	√	-	-	√	√	√	√	-	√	√	√		√	√
Unattended Operat'n Setup	√	√	-	√	√	√	-	√	√	√	√	-	√	√	-	√		-	√	√
Security-Data Encryption Protection																				
DES (Private Key)	-	-	-	-		-	-	-	√	-	-	-	-	-	-	-	-	-	-	-
RSA (Public Key)	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Security-Data Access Protection																				
Password Protection	√	-	-		√	√	√	-	-	√	-	√	-	-	√	√	-	√	-	√
Multiple Level Password	-	-	-	-		√	√	-	-	-	-	-	-	-	-	-	√	-	-	-
Callback	√	-		√	√	-	-	√	-	√	-	-	-	-	-	-	-	-	-	-
Access Security within Unattended Operations	√	-	-	√	√	√	√	-	√	-	√	-	-	√	-	-	√	-	√	-
Interactive Special Knowledge		-	-			-		-		-	-	-	-	-	-	-	-	-		
File Transfer Statuses																				
Character Counts	√	√	√	-		-	√		√	-	-				-		√	√		√
Percent of File Transferred	√	√	-	√		-	√		-	-	-				-		-	-		-
Number of Errors	√	√	√	√		√	√		-	√	√				-		√	√	√	√
Other Features																				
Data Capture	√	√	√	√		√	√	√	√	√	√	√	√	√	√	•P	√	√	√	√
Unattend File Transmis'n	√	√	-	√		√	√	-	√	√	-	-		√	√			-	√	√
Remote Unattend Operat'n	√		-	√	-	√	√	√	√	√	-			√	√			-	√	√
Toggle Printer ON/OFF	√	√	√		√	√	√	√	√	√	√	√	√	√			√	-	√	√
Display Clock	√	-	-	√		-	√	-	-	-	√	-	-	√	√		√	-	√	-

* Mandatory features

•P Proprietary

Functions vs. Communications Software

The table shown on the previous page consists of the evaluation results of the micro communications software packages, evaluated against the given functional criteria.

MICRO COMMUNICATIONS PACKAGES	
Functions vs. Software Matrix	
Communications Packages **Listed:**	
A.	ASCII-PRO
B.	ASCOM IV
C.	BLAST
D.	CROSSTALK
E.	HYPERACCESS
F.	IMPERSONATOR
G.	INTELLITERM
H.	KERMIT
I.	LYNC
J.	MITE
K.	OMNITERM II
L.	PC-TALK III
M.	PERFECT LINK
N.	RELAY
O.	SMARTCOM II
P.	SMARTERM 100, 125, 400
Q.	SOFTERM
R.	TANGO
S.	TRANSEND PC COMPLETE
T.	VTERM III

The following is a key for the Function vs. Software Matrix:

√ - yes

- - no

<blank> - undetermined

4.2. PROBLEMS ENCOUNTERED

* **DDN Usage**

    In integrating with the LOGNET program, severe performance problems were encountered when using the selected file transfer protocols, going through DDN for host-to-host transfers. This limits the generic solution of using only the above specified protocols for all file transfers.

    Fortunately, FTP is an alternative solution when transferring files from host to host using the DDN. This protocol is the recommended military standard for inter-mainframe file transfers.

    Section 3.4.1.2 discusses why FTP is not currently being considered as a viable solution for file transfers using microcomputers.

* **Resumption of File Transmission after Involuntary shutdown**

    Resumption of file transmission from point of interruption after an involuntary shutdown or disconnection of a communication link is a requirement specified in the AFLC Statement of Work. We encountered only one protocol (BLAST) which claimed to handle this type of transmission interruption.

    We do not recommend that this feature disqualify good candidates for the proposed solution. If necessary, we recommend a waiver to the standard for this feature, until industry has implemented this feature on a wider basis.

* **Data Compression Capability**

    The ability to perform data compression on a file prior to file transmission was not a feature found among the protocols or communications software that were evaluated. This feature is more commonly found at session levels of communication links (e.g., in modems or other communications equipment), or as separate system function (*compress/decompress*) that can optionally be performed prior to or at the end of a file transfer operation.

* **Data Encryption Capability**

    While data encryption is not a mandatory requirement, it does address some of the security issues of data in transit. The capability to perform data encryption on a file prior to transmission, and decryption upon receipt of a file, was not a feature found in micro communications software. This feature is probably more common at the equipment level (e.g. modem or other communications equipment) or as a separate system function (*encrypt/decrypt*) that can optionally be performed prior to or at the end of a file transfer operation.

4.3. CONCLUSIONS

This section describes the reasons for the selection of specific file transfer protocols and communications software packages for the cost/trade-off analysis effort, which will include hands-on evaluation of each package. It also describes how the functionality was selected for inclusion into the MMCS draft standard.

4.3.1. Selection of File Transfer Protocols for Cost/Trade-off Analysis

The following were selected as the recommended file transfer protocols for the Air Force:

1. **Kermit Protocol**
   - This protocol satisfies many of the SOW functional criteria.
   - This protocol is available in the public domain from Columbia University.
   - It is widely implemented in commercially available and supported software packages.
   - According to Columbia University, it is implemented on all of the host mainframes required by the SOW.

2. **Blast Protocol**
   - This is the protocol that addresses the most functional criteria required by the SOW.
   - It is a full-duplex interleaving protocol, thereby increasing file transfer performance.
   - It is implemented on most of the required host mainframes in the SOW, and supported by the vendor.
   - According to its product descriptions, this protocol provides for resumption of file transmission in the event of interrupted file transfer. This is the only protocol we found to support this function.

   However, we have the following reservations regarding this protocol:
   - The protocol specification is proprietary to Communications Research Group (CRG), Inc., making it tightly bound to the vendor products.
   - The software implementation of the Blast protocol is not as user-friendly as other comparable commercial software.
   - It took us three attempts to install this product. This may be an indication of poor product and documentation quality and an inadequate level of support provided by CRG.

3. **Christensen Protocol**
   - Also known as XMODEM, this protocol is the *de facto* industry standard for microcomputer file transfers. Most vendors that offer micro communications features and modem software packages have this protocol included as a feature.
   - This protocol was chosen for its widespread availability and support.
   - Where all other protocols and packages fail to provide for a communication link for a particular micro-mainframe combination, this particular protocol could be used as a fallback solution.

4.3.2. Selection of Software Packages for Cost/Trade-off Analysis

In examining the functional matrices and the evaluation results, the packages selected to be evaluated are the following:

For a general communications package that supports PC-DOS and MS-DOS, Kermit and Christensen (XMODEM) file transfer protocols, and has TTY terminal emulation, VT100 series emulation and IBM 3101 emulation:

- **Ascii Pro**
- **Crosstalk**
- **MITE**
- **BLAST**

    Only supports its own proprietary file transfer protocol. Has support for both asynchronous transmissions and for synchronous links using a proprietary 'Blast Box' to connect to an IBM processor. This should be considered as an alternative approach to the public domain/widespread availability of Kermit and Christensen (XMODEM).

The following products are being considered for the Z-DOS solution:

- **HyperAccess**

    Additionally, supports MS/PC-DOS, Christensen (XMODEM) and Kermit protocols.

- **LYNC**

    Supports the Christensen (XMODEM) protocol only.

- **KERMIT**

    One of the few Z-DOS software packages that supports the Kermit protocol. Its documentation indicates availability of versions for all the mainframe hosts required by the SOW.

LYNC, KERMIT, and HyperAccess provide the Z-DOS solution. All the other packages generally have support for MS-DOS and PC-DOS, and offer TTY emulation, DEC VT100 series emulation, and less frequently, IBM 3101 emulation.

4.3.3. Selection of Functionality for MMCS Standard

Next, we examined functions that are currently available in the industry, that might be included in the MMCS functional standard.

One example of such a functionality that is not a SOW requirement, is support for the higher communication baud rates. Since there are a considerable number of software packages that include support for up to 19.2 kilobaud, we considered this feature for possible inclusion in the draft standard.

Initially, the draft standard contained the SOW requirements per the MMCS project implementation plan. The standard included specifying support for the given host mainframe systems and the micro operating systems. We then added the minimum functionality recommended for file transfer and terminal emulations, based on a composite of available functions in currently available software packages.

4.4. CONSIDERATIONS

While micro-to-mainframe links offer convenient access and flexibility in working environments, there are some issues that should be considered when investigating their possible use for some applications. For groups using these applications, it may be advisable to create guidelines which address these issues.

- **SECURITY**

    One of the issues that has kept many data processing shops from going into distributed processing is the question of security. Access to mainframe data can be controlled through system administration. This can be controlled as long as the data resides in the mainframe. However, when mainframe data is accessed from a micro or PC acting as a terminal, and captured onto a micro or PC file, control over this information is distributed to the micro end user. The security of the captured data is then as good as the security with which the micro user accords it. Essentially, there cannot be effective security controls when data is distributed among multiple microcomputers or workstations.

    Some of the security implications arising from micro-mainframe links usage are:
    - distribution of data implies distribution of access control,
    - physical security of data on diskettes or floppies is difficult to maintain,
    - data is safer in the mainframe because of security which normally surrounds mainframes (both physical and administrative controls),
    - better security access, procedures and policies will encourage wider use of micro-to-mainframe links.

    There are some methods that can be employed to circumvent some access and data security problems with networks, distributed environments, or in normal communication links.

    - **Password protection**

        May be used to control entry into a network, mainframe, or database with varying levels of access.

    - **Encryption of disk files**

        Although an intruder may still succeed in gaining entry into a system, encrypted files on the system can thwart someone from freely perusing through files.

    - **Encryption of data in transit**

        Data traveling over any network medium or communication lines can be tapped by data thieves. Encrypting the data prior to transmission can protect the information while in transit.

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This section is organized into the following four major subsections:

- **MMCS Project Documentation**
  Lists all MMCS project documentation, both internal and external, including some official correspondence.

- **Standards & Specifications**
  Contains references to related military standards, Air Force standards, or standards organizations' documents.

- **Articles & Publications**
  Contains citations for magazine articles, news articles or columns, software or product reviews, commentaries, publications in books, technical journals or conference proceedings.

- **Product Literature**
  This is a collection of references to specific products in the way of descriptions, product brochures, specifications, or product manuals. These literature is associated with the products addressed in this document for file transfer protocols and communications software.

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GLOSSARY

Glossary

Term / Acronym	Explanation
ACK	Acknowledge. Where error detection schemes are employed, a message sent in response to having received the transmission intact and without error.
AFB	Air Force Base.
AFLC	Air Force Logistics Command.
AFSC	Air Force Systems Command.
ANSI	American National Standards Institute.
ARPANET	Advanced Research Projects Agency (ARPA) network.
ASCII	American Standard Code for Information Interchange. A coding scheme consisting of 7-bit elements representing letters, numbers and special symbols, allowing for standardization among data communications devices and systems.
AT&T	American Telephone and Telegraph Company.
baud	A measure of transmission speed that roughly equals bits per second (bps).
BLAST	BLocked ASynchronous Transmission. From Communications Research Group, a full-duplex transmission protocol permitting a number of unacknowledged blocks to be outstanding.
Bell 103	AT&T's modem standard for 300 bps data communications that is widely adopted by industry.
Bell 212A	AT&T's modem standard for 1200 bps data communications that is widely adopted by industry.
bps	Bits per second.
CCITT	International Telegraph and Telephone Consultative Committee (translates from the original French); an international telecommunications standards organization based in Geneva, Switzerland.
CDC	Control Data Corporation.
CDRL	Contract Data Requirements List.
CP/M	A micro-based operating system; exists in two versions: CP/M 80 which runs on an 8-bit 8080 processor, and CP/M 86 which runs on a 16-bit 8086/8 processor.

CRC	Cyclic redundancy checksum. Used in error detection schemes for data communications. The CRC is a value (typically 16-bit) generated by applying a polynomial function to the bytes of the message being transmitted. This computed value sent along with the data and compared by the receiving end to the CRC computed from the received message bytes.
DCE	Data communications equipment. At a lower electrical interface level, this might also be referred to as data circuit equipment.
DDN	Defense Data Network. A collection of networks (ARPANET, MILNET) operated by the Defense Communications Agency (DCA) that use a common protocol set. DDN is used for the exchange of research and contractor information for government, laboratories and research institutions involved in DOD contracts.
DEC	Digital Equipment Corporation.
DES	Data Encryption Standard; a private key encryption technique commonly implemented today.
DOD	Department of Defense.
DTE	Data terminal equipment. At a lower electrical interface level, this may also be referred to as data terminating equipment.
EIA	Electronic Industries Association. An organization out of Washington D.C. that defines and specifies electronic engineering standards.
FTP	File Transfer Protocol. Defined in MIL-STD 1780.
full duplex	A data communications mode of transmission that allows for simultaneous movement of data in both directions.
IAW	In accordance with.
IBM	International Business Machines.
IP	Internet Protocol. Defined in MIL-STD 1777.
ISO	International Organization for Standardization.
half duplex	A data communications mode of transmission that allows for movement of data in both directions, but in a single direction only at any point in time.
HDLC	High-level Data Link Control. A link protocol defined by the International Organization for Standardization (ISO).
HQ AFLC	Headquarters Air Force Logistics Command, Wright-Patterson Air Force Base, OH.
HTPE	High-Technology Performance Evaluation.
ISG	Intersite gateway.
ISO	International Organization for Standardization.

Kermit	A file transfer protocol and program developed at Columbia University. It is available in the public domain. The protocol is full-duplex with error detection and recovery schemes.
LAN	Local area network.
LLNL	Lawrence Livermore National Laboratory, Livermore, CA.
LMS	Logistics Management Systems.
LMSC	Logistics Management Systems Center.
LOGNET	Air Force Logistics Network. This network interlinks the AFLC computers and office systems to support logistics requirements.
MIL-STD	Military Standard.
MMCS	Micro-to-mainframe communication standard.
MNP	Microcom Networking Protocol. Microcom Inc.'s full-duplex session-level protocol that uses the cyclic redundancy check (CRC) in its error detection and correction scheme. MNP is supported by Telenet, and is licensed out by Microcom.
MS-DOS	MicroSoft's Disk Operating System, a micro-based operating system.
MVS/SP	IBM's Multi-User Virtual System / Systems Product.
MVS/XA	IBM's Multi-User Virtual System / Extended Architecture.
NAK	Negative Acknowledgment. Used to indicate a fault in reception where there are error detection schemes employed and a transmission is received with error.
network	A system of interconnected computers and terminals or workstations.
NOS/BE	Control Data's Network Operating System / Batch Environment for the Cyber series mainframes (successor to SCOPE 3.4).
OS 1100 EXEC	Sperry's operating system for the Sperry UNIVAC 1100 series mainframes.
OSI	Open system interconnection. ISO's seven-layer model for the networks.
packet-switching	A transmission method commonly used in LANs or public networks that divides messages into standard-sized pieces (called "packets") for greater efficiency in network throughput.
PC-DOS	IBM MS-DOS based operating system developed for the IBM PC.
RSA	A public key data encryption technique used today.
RS-232C	A serial interface standard defined by the Electronic Industry Association (EIA). The RS-232C interface is a 25-pin connector that supports transmission at data rates up to 20,000 bps at distances up to 50 feet between DTE and DCE.

SDLC	Synchronous Data Link Control. IBM's link protocol for synchronous data communications.
SMTP	Simple Mail Transfer Protocol.
SOH	Start-of-header.
SOW	Statement of Work document.
OS 1100 EXEC	Sperry's operating system for the Sperry UNIVAC 1100 series mainframes.
TBD	To be determined.
TCP	Transmission Control Protocol. Defined in MIL-STD 1778.
TELNET	A communications protocol supported on ARPANET.
TIS	Technology Information Systems.
TSO	IBM's Timesharing Option, available on IBM's mainframe systems.
TTY	Historically refers to the ancient teletype device that functioned as an on-line terminal using line-by-line interaction mode.
Tymnet	A public communications network that provides data communications services.
VAX/VMS	DEC's VMS operating system for the VAX series mainframes.
VM/CMS	IBM's Virtual Memory Conversational Monitor System.
VT100	DEC's Video Terminal model. There exists a wide availability of VT100 series terminal emulation in the industry.
V.22	CCITT's recommended standard for a 1200-bps modem, full-duplex transmission, for switched network operation or over point-to-point 2-wire leased lines.
V.22 *bis*	CCITT's recommended standard for a 2400 bps modem, full-duplex transmission, using the frequency division technique, for use in switched network operation or over point-to-point 2-wire leased lines.
V.24	CCITT's standard for interchange circuits between DTEs and DCEs for binary, control and timing, and analog signals. V.24 is a rough equivalent of EIA's RS-232C serial interface definition.
V.26	CCITT's recommended standard for a 2400 bps modem for use on 4-wire point-to-point or multipoint leased lines.
V.26 *bis*	CCITT's recommended standard for a 2400/1200 bps modem for switched network operation.
V.27	CCITT's recommended standard for a 4800 bps modem with manual equalizer for half- or full-duplex operation over a 4-wire leased line.

V.27 *bis*	CCITT's recommended standard for a 4800/2400 bps modem with automatic adaptive equalizer for half- or full-duplex operation over a 4-wire leased line or half-duplex operation over a 2-wire leased line.
V.27 *ter*	CCITT's recommended standard for a 4800/2400 bps modem with automatic adaptive equalizer for switched network operation.
V.29	CCITT's recommended standard for a 9600 bps modem with automatic adaptive equalizer for point-to-point operation, half- or full-duplex over a 4-wire leased line.
V.32	CCITT's recommended standard for a family of 2-wire, duplex modems operating at data signalling rates of up to 9600 bps for switched network operation or on leased lines. Currently specified for synchronous 2400/4800/9600 bps. Asynchronous mode of operation is noted for further study.
WPAFB	Wright-Patterson Air Force Base, Dayton, Ohio.
XMODEM	A popular file transfer protocol utilizing a cyclic redundancy checking (CRC) algorithm for error detection. Also known as the Christensen protocol, or sometimes, as MODEM7.
XON/XOFF	Restart/pause functions in data transmission.
X.PC	A full-duplex session-level protocol from Tymnet that operates throughout a communications session with error detection and correction. This protocol is available in the public domain.
X.25	A univerally accepted protocol used in synchronous, packet-switched transmission services provided by public data networks.
Z-DOS	Zenith's Disk Operating System for Z100-based processors.